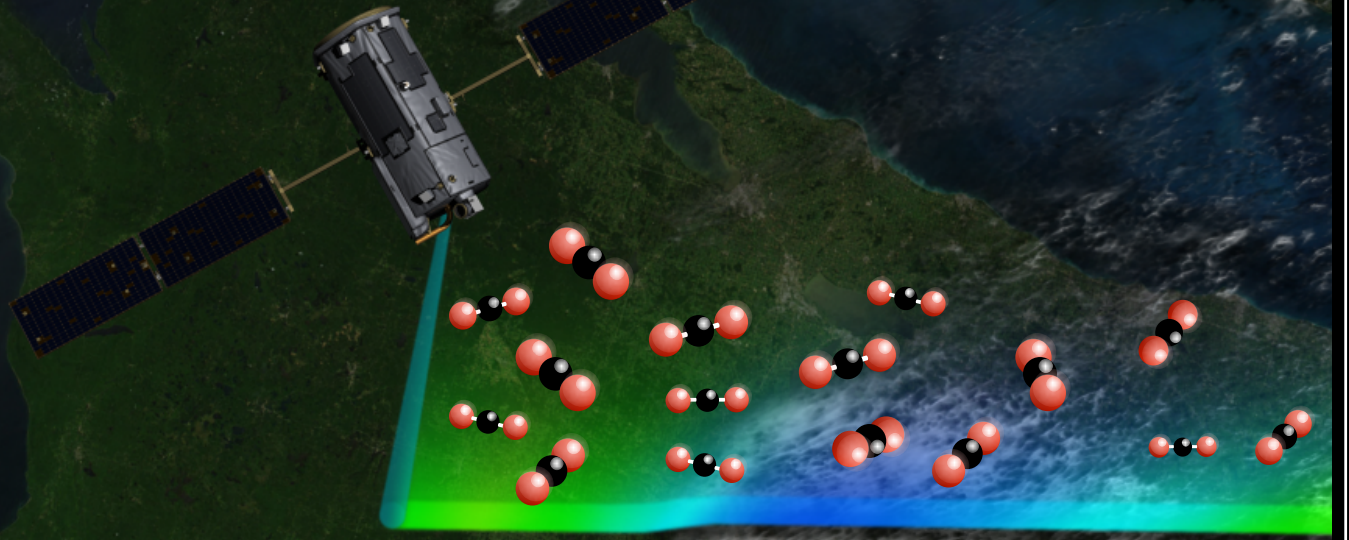
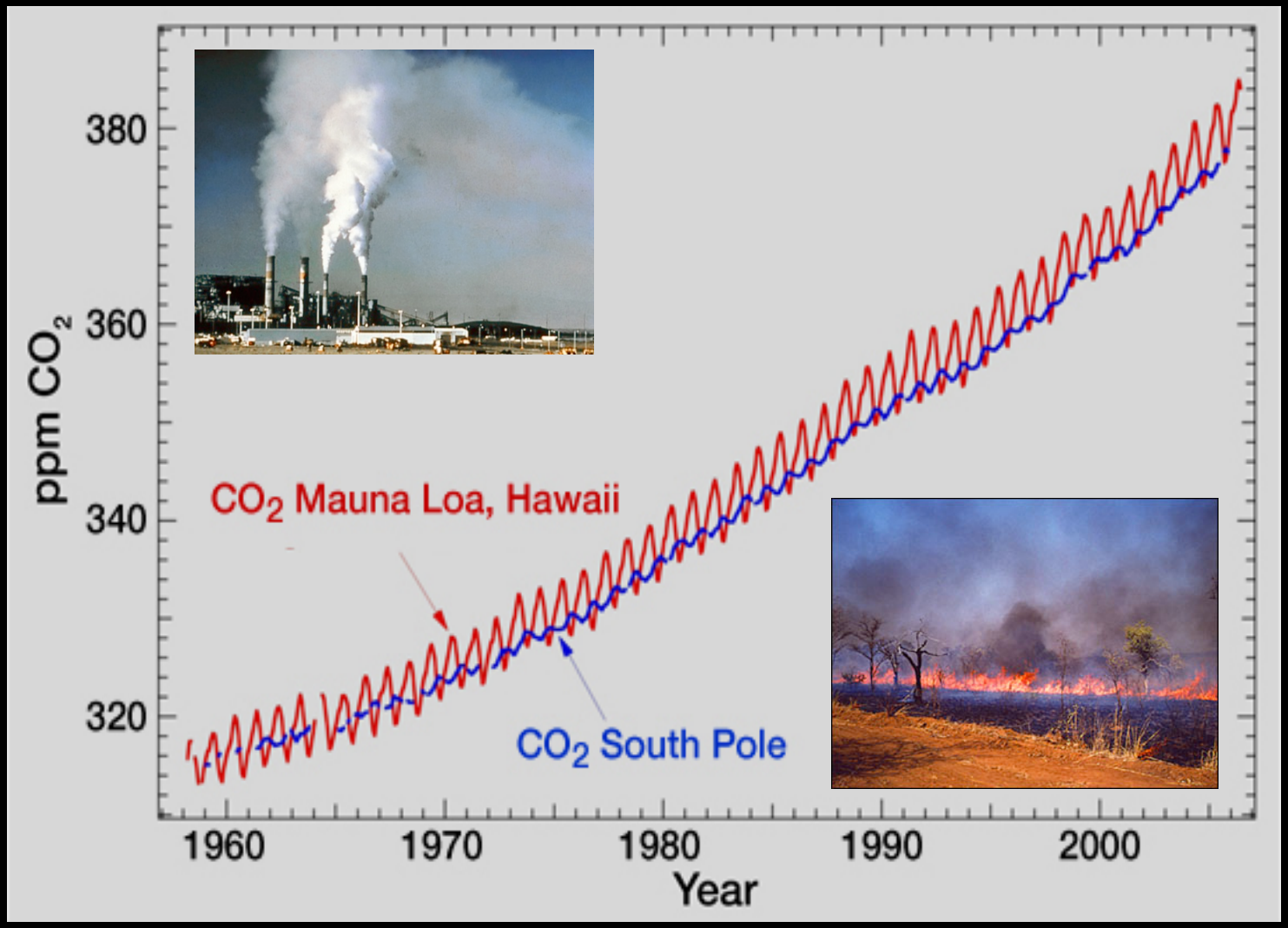
AIAA 2010: Future Earth Science Missions and Enabling Activities

The Orbiting Carbon Observatory-2 (OCO-2) Mission

Watching The Earth Breathe…Mapping CO_2 From Space



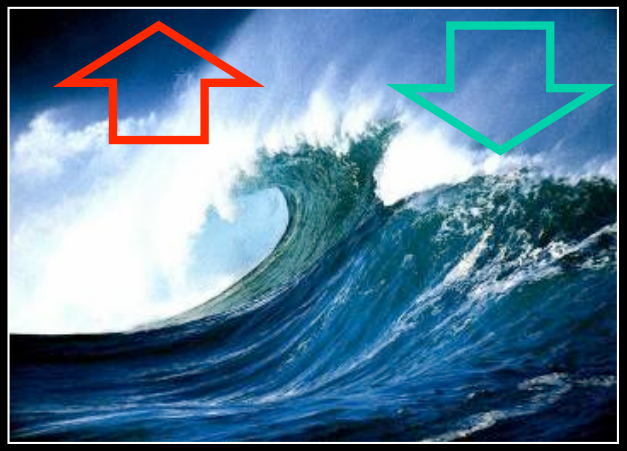
David Crisp (JPL)
OCO-2 Science Lead
September 1, 2010



Fossil fuel use and deforestation are adding more than 30 billion tons of carbon dioxide to the atmosphere every year

What Controls Atmospheric Carbon Dioxide?

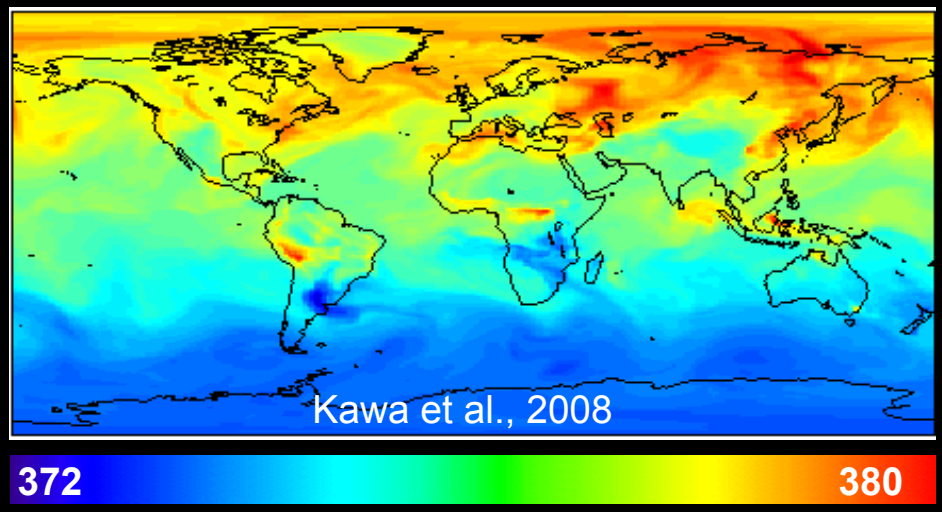
- Natural systems including the ocean and plants on land both absorb and emit carbon dioxide to the atmosphere
- Currently, these natural systems are absorbing about half of the carbon dioxide emitted by human activities
- These natural carbon dioxide “sinks” are limiting the rate of carbon dioxide buildup and its impact on the Earth’s climate
- We do not yet know:
  - Exactly where the carbon dioxide is being emitted and absorbed
  - How much longer natural processes will continue to absorb the carbon dioxide that we emit in the presence of climate change



Global Measurements are Essential

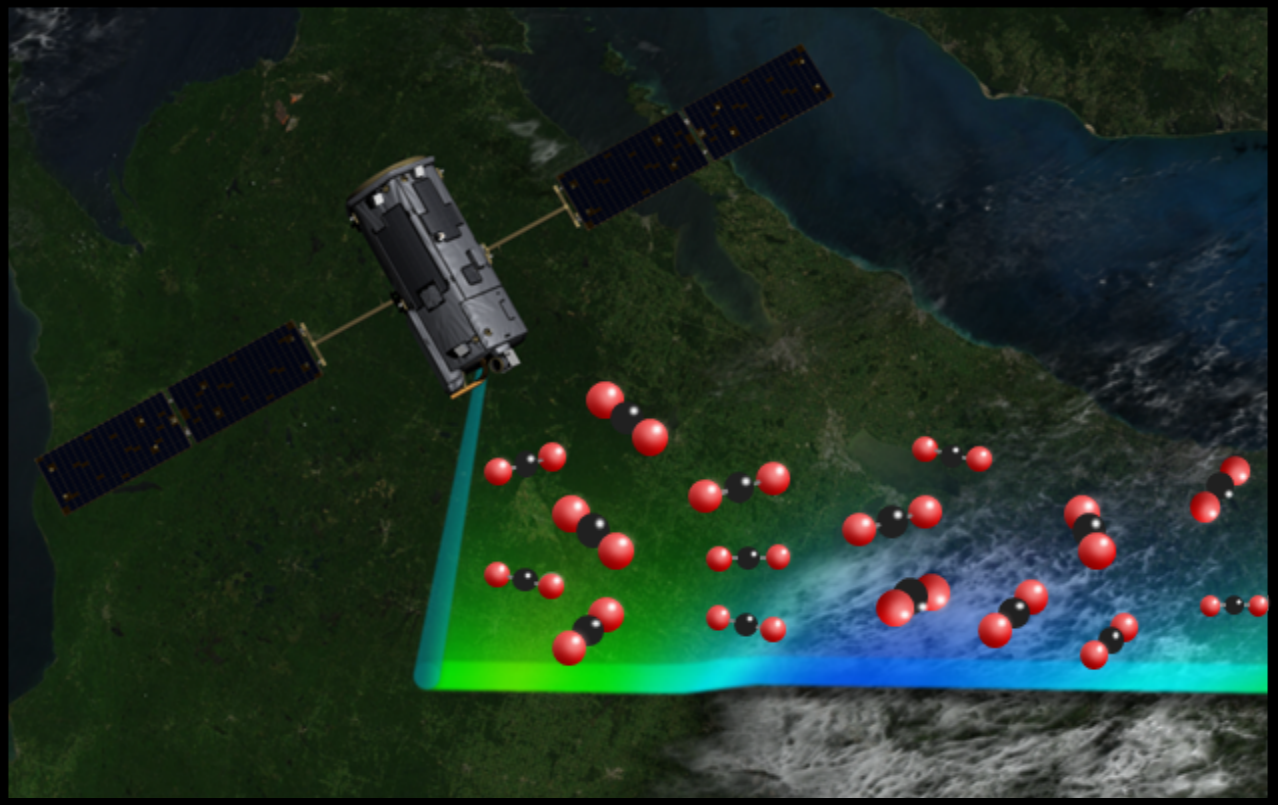
- To limit the rate of atmospheric carbon dioxide buildup, we must
  - Control emissions associated with human activities
  - Understand & exploit natural processes that absorb carbon dioxide
- We cannot manage what we cannot measure
- Identifying sources and sinks of atmospheric carbon dioxide from atmospheric measurements is intrinsically challenging

Plumes from medium-sized power plants (4 MtC/yr) elevate X_{CO2} levels by ~0.5% (2ppm) for 10's of km downwind [Yang and Fung, 2010].



Variations of CO_2 are rarely larger than 1-2% on 100 – 1000 km scales

The NASA Orbiting Carbon Observatory (OCO)

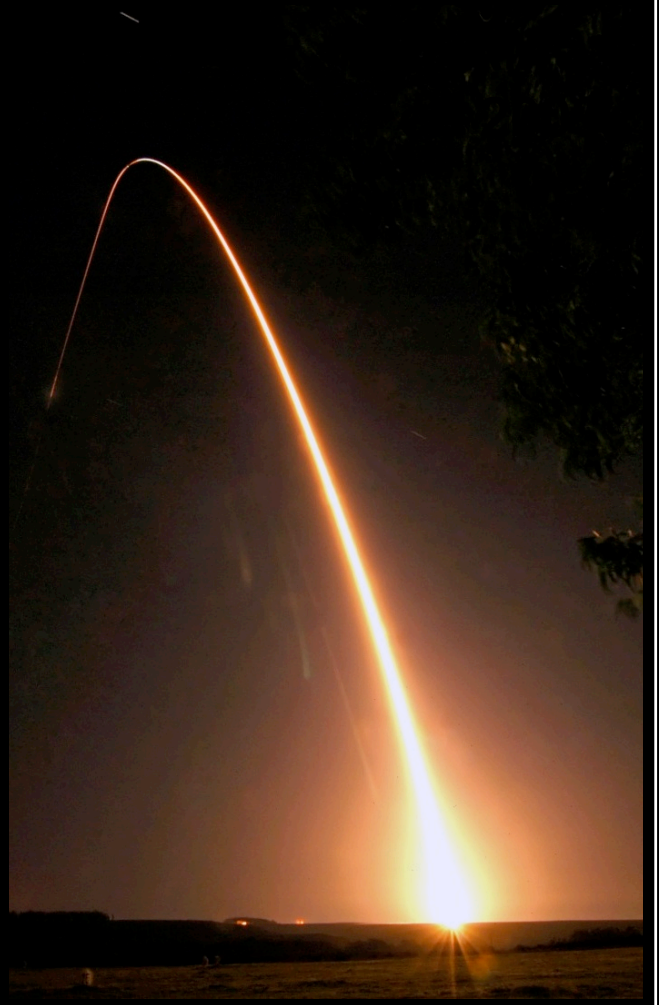


NASA's Orbiting Carbon Observatory (OCO) was designed to provide global estimates of atmospheric carbon dioxide (CO_2) with the sensitivity, accuracy and sampling density needed to quantify regional scale carbon sources and sinks and characterize their behavior over the annual cycle.

The Loss of OCO

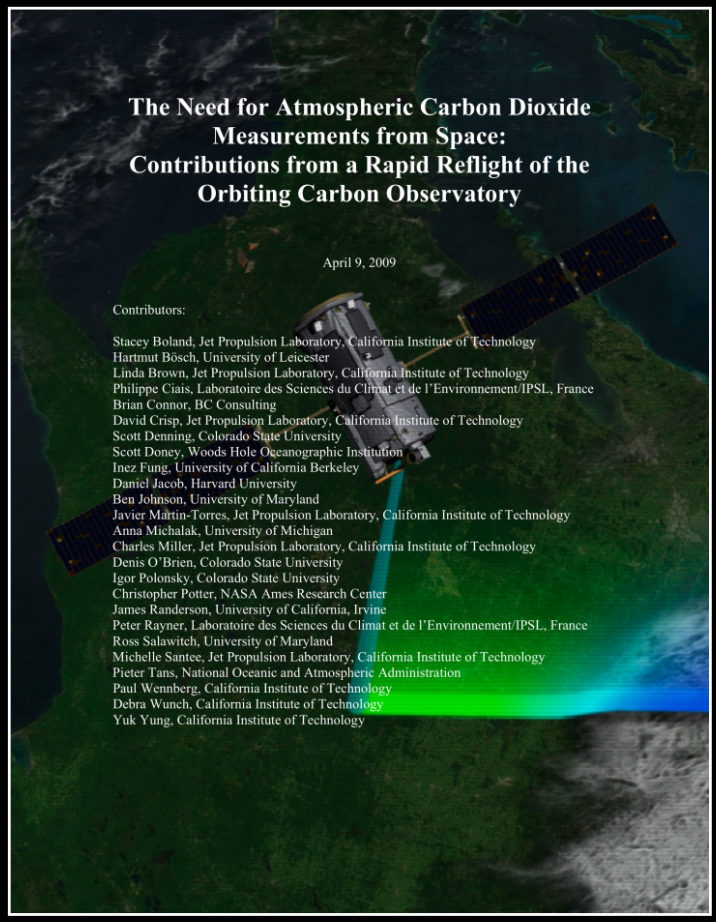
OCO launched from Vandenberg AFB 2/24/09

- The launch vehicle payload fairing was scheduled to separate ~3 minutes after launch
  - telemetry provided no positive indication
- The launch vehicle failed to reach orbital velocity providing corroborating evidence of excess mass being carried into space
- NASA commissioned a Mishap Investigation Board to determine the root cause of the anomaly and recommend corrective actions
  - No root cause was identified, but 4 “Potential Intermediate Causes” were found
- NASA Launch Services is working to improve the reliability of the Taurus XL launch before the next scheduled launch (Glory, Late 2010)



Justification for an OCO Re-flight

- Accurate and precise measurements of carbon dioxide sources and sinks is of paramount importance
- Despite progress, our knowledge is limited by the lack of high precision global measurements of atmospheric carbon dioxide
- While there have been advances in space-based measurements there is no existing or confirmed sensor capable of quantifying carbon dioxide sources and sinks



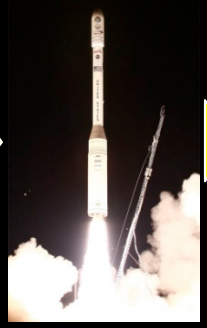
A re-flight of a "carbon copy" of OCO meets science and policy imperatives at the lowest cost, and on the fastest possible schedule

OCO-2 Mission Overview

3-Channel Spectrometer (JPL)

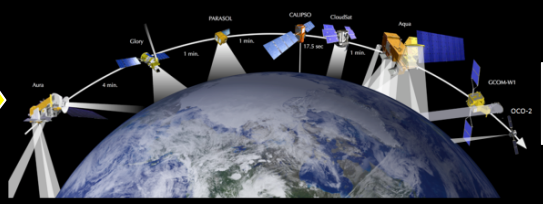
Dedicated Spacecraft bus (OSC)

Dedicated Launch Vehicle



Mission Operations (OSC)

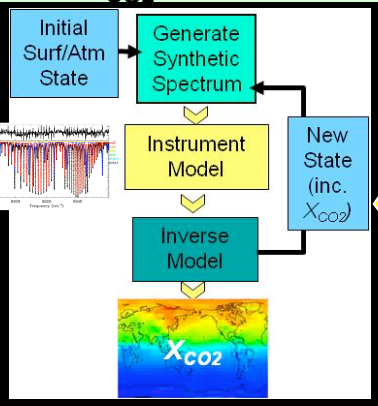
Formation Flying as part of the A-Train Constellation



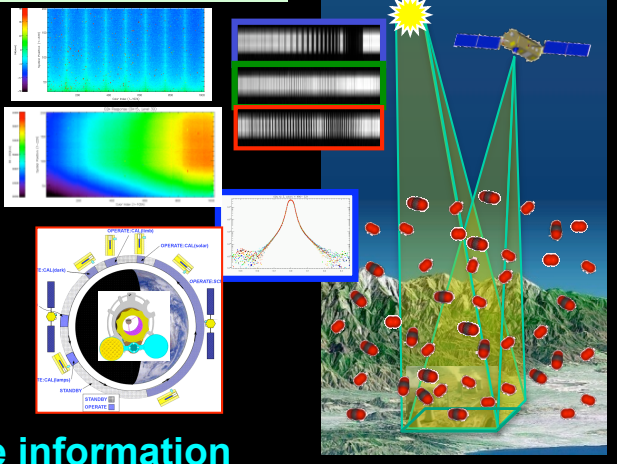
NASA NEN (GSFC) and SN (TDRSS)

Science Data Operations Center (JPL)

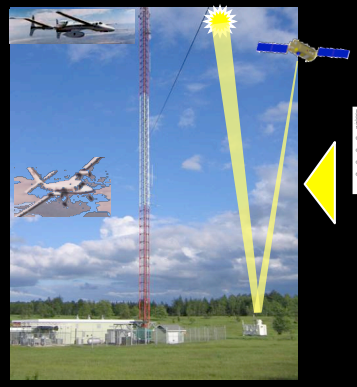
L2 X_{CO2} Retrieval



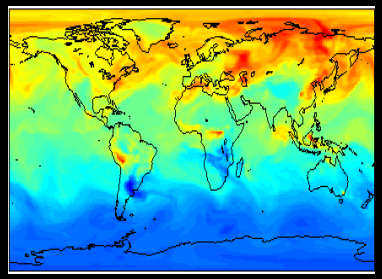
Calibrate Data



Validation Program



Products Delivered to a NASA Archive



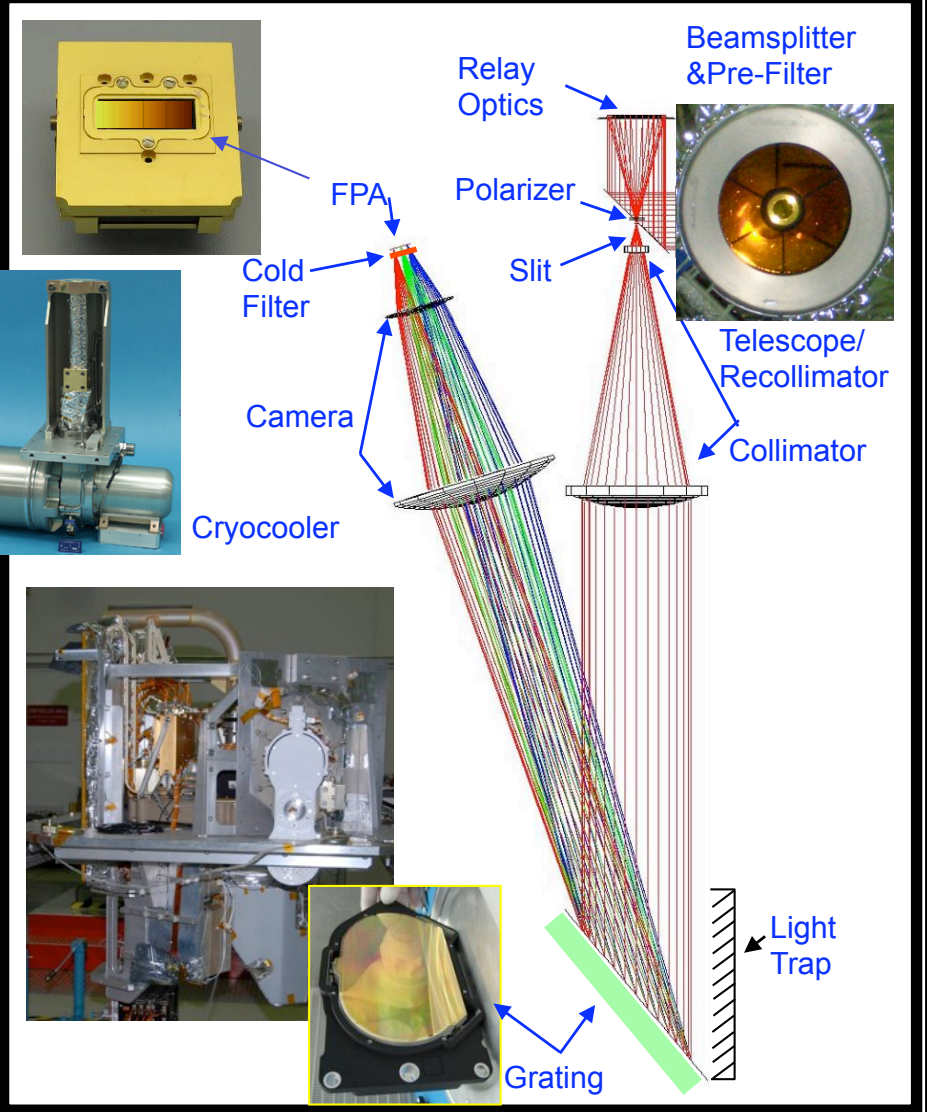
Please visit http://oco.jpl.nasa.gov for more information

Same Instrument

- 3 co-bore-sighted, high resolution, imaging grating spectrometers
  - O_2 0.765 μm A-band
  - CO_2 1.61 μm band
  - CO_2 2.06 μm band
- Resolving Power > 20,000
- Optically fast: f/1.8 (high SNR)
- Swath: < 0.8° (10.6 km at nadir)
  - 8 cross-track footprints
  - 1.29 x 2.25 km at nadir
- Mass: 140 kg, Power: ~105 W

Changes from OCO

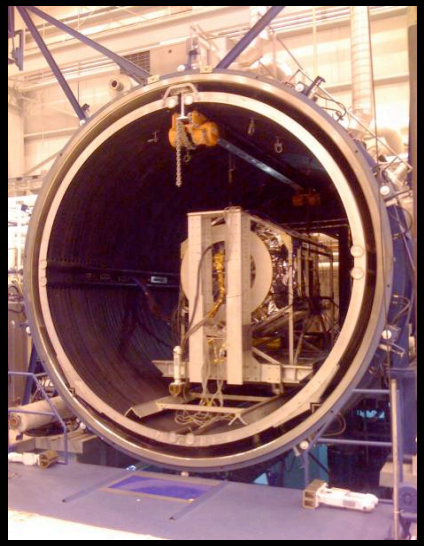
- New focal plane arrays (FPA's)
- New cryocooler



Same Spacecraft

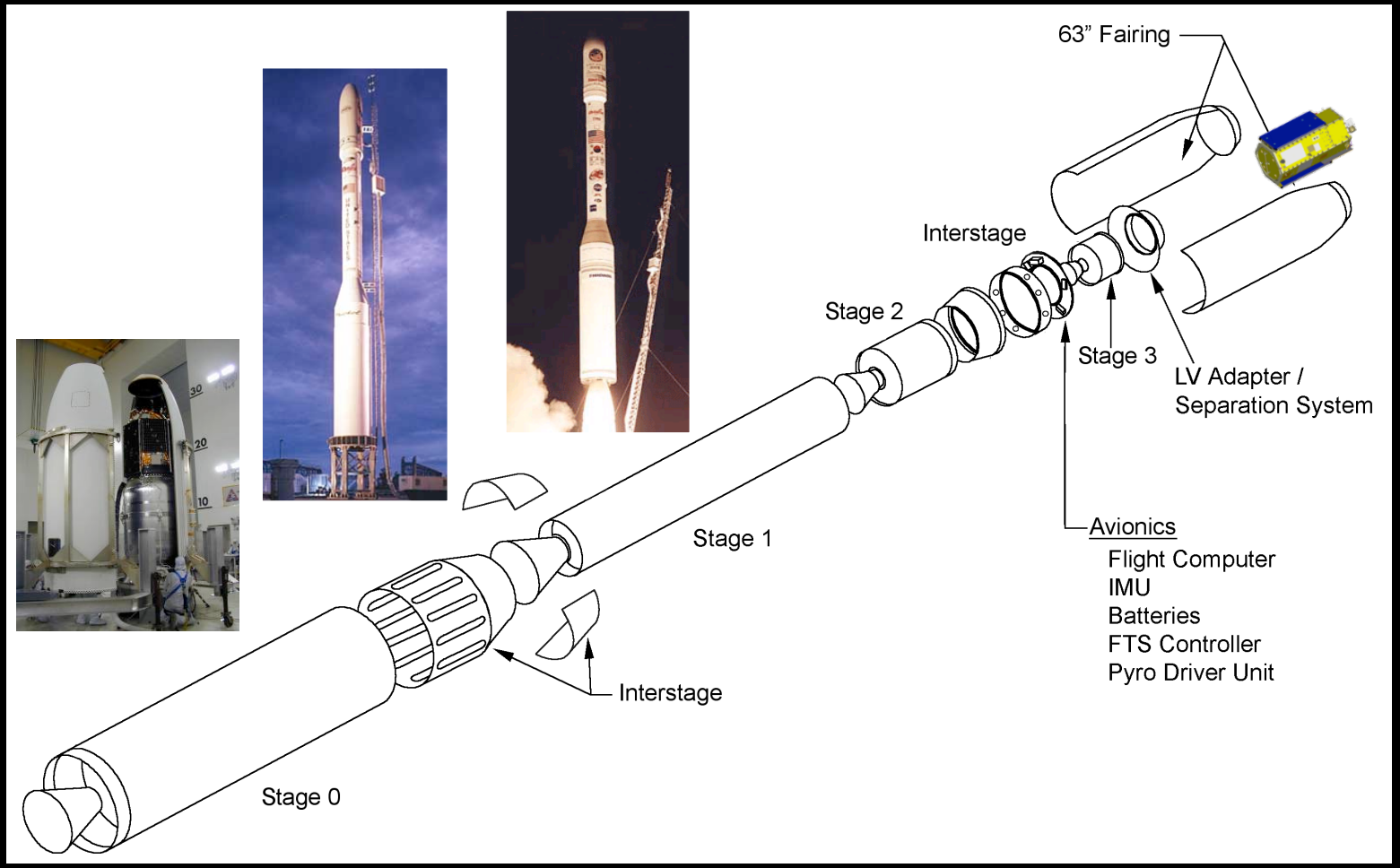
Minimal changes to update obsolete parts

- Orbital Sciences LEOStar-2 Bus
  - 0.94 m x 2.1 m
  - 128 Gb of data storage
  - 3-axis stabilized
  - Articulated solar arrays
  - Includes propulsion system for orbit maintenance

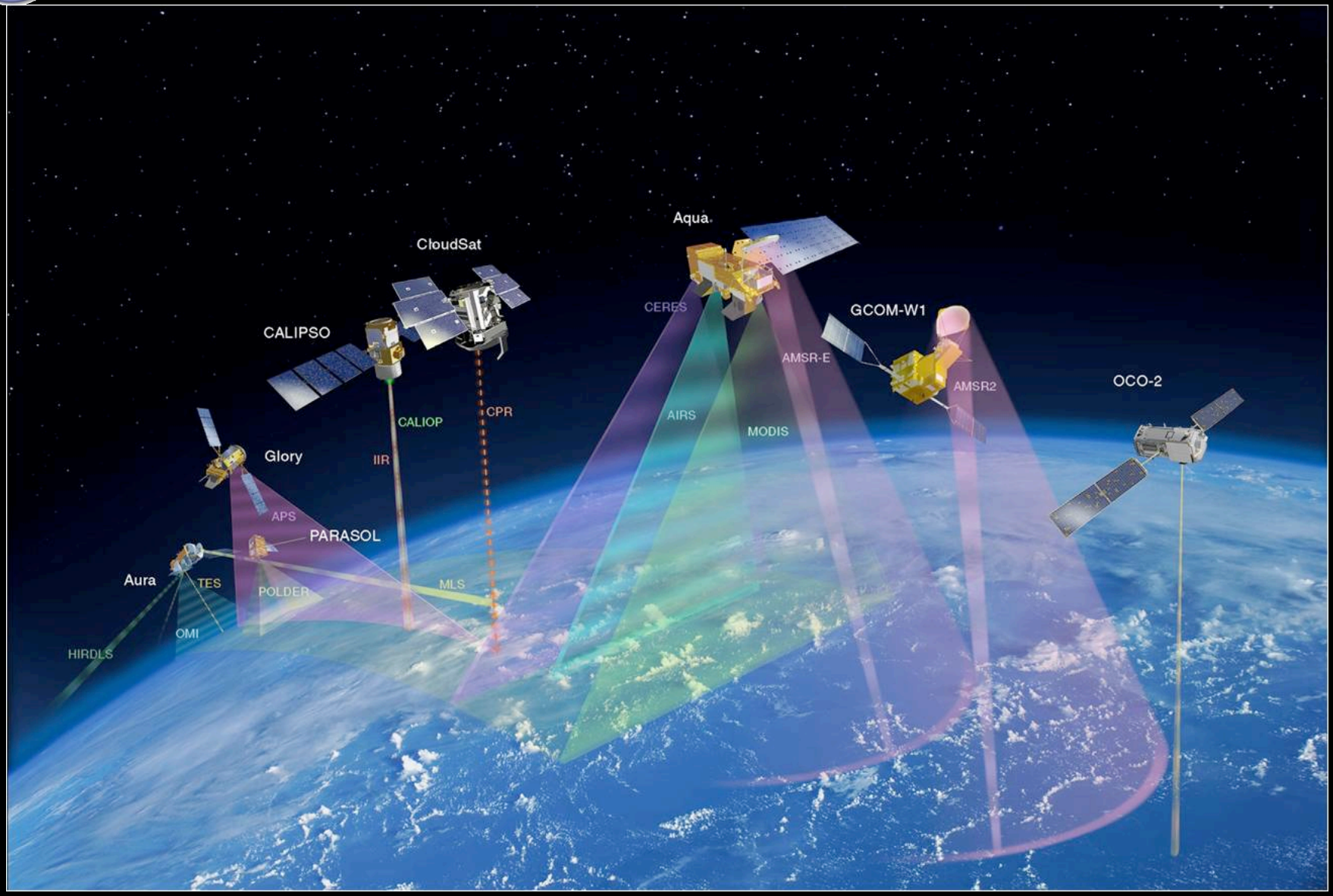


Same Launch Vehicle

Orbital Sciences Corporation will provide another Taurus 3110

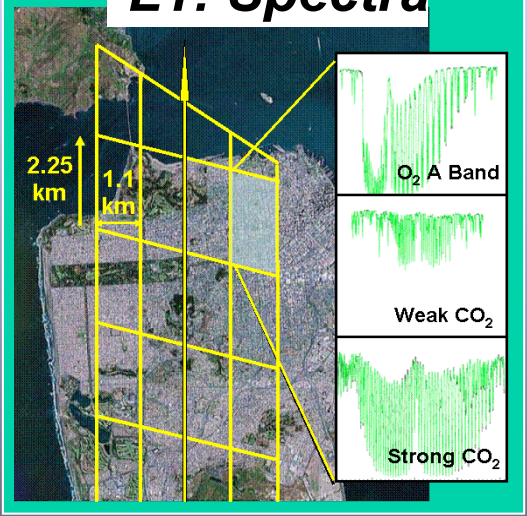


Still Flying at the Head of the A-Train

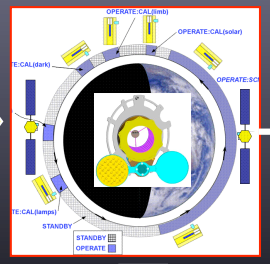


Faster Data Product Delivery Schedule

L1: Spectra



Calibration



L2: X_{CO2} Retrievals

Initial State

Generate synthetic spectrum

Instrument Model

Inverse Model

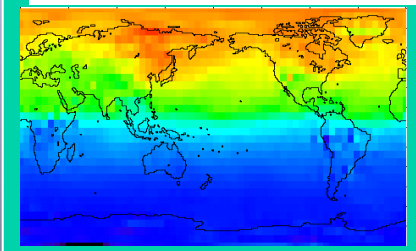
X_{CO2}

New State (inc. X_{CO2})

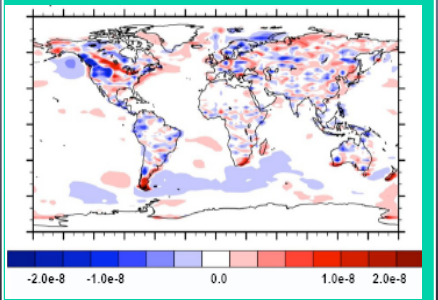
Validation

Source/Sink Inversion

L3: X_{CO2} Maps



L4: Sources/Sinks



IOC+3 Months | L1B+3 Months | As Available

The OCO-2 Status and Plans

- December 2009: The U.S. Congress added funding to the NASA FY2010 budget to restart the OCO Mission
- February 2010: The President's 2011 NASA budget proposal included funding for a "Carbon Copy" of the OCO mission, now designated "OCO-2," with a launch date "no later than February 2013"
- The OCO-2 mission is currently in development
  - Instrument and spacecraft components are on order
  - The launch vehicle has been selected through a competitive process
  - A Critical Design Review was conducted on August 25-26, 2010
  - Mission Implementation Phase is expected to begin on October 1, 2010
- By this time next year, the OCO instrument and spacecraft bus will be ready to begin their pre-flight testing in space simulation chambers at JPL and Orbital Sciences Corporation
- OCO-2 is on track to meet a February 2013 Launch Readiness Date